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WSP

SB-6
11/24/10

November 24, 2010

P. Scott Burton, Esq.
Hunton & Williams, LLP
550 S. Hope Street, Suite 2000
Los Angeles, CA 90071-2627

Re: Electrical Resistivity Imaging Summary and Proposed Seismic Reflection Survey
Nu-West Industries, Inc. CPO Facility, Soda Springs, Idaho

Dear Scott:

This letter report summarizes the scope and findings of the electrical resistivity imaging (ERI) survey conducted at the Nu-West Industries, Inc. (Nu-West) Conda Phosphate Operations (CPO) facility in Soda Springs, Idaho. The ERI survey was performed in accordance with the scope of work described in the revised Sampling and Analysis Work Plan for Site Characterization (Work Plan) for the CPO facility, dated June 20, 2010. The U.S. Environmental Protection Agency (EPA) approved the Work Plan by letter dated July 2, 2010. Below are summaries of the survey implementation methods and the key findings. These summaries are followed by a preliminary proposal for a seismic reflection (SR) survey to further evaluate key features (conductive anomalies) identified in the ERI survey.

Electrical Resistivity Imaging Survey

Under the direction of WSP Environment & Energy (WSP), Enviroscan, Inc. (Enviroscan) conducted the ERI survey in two phases between July 19, 2010 and October 9, 2010. The goals of the ERI survey were to: (i) identify and map the extent of fracturing and weathering within the basalt sequence and associated faults that may serve as preferential flow pathways of groundwater below the Site; (ii) identify the zones within the basalt sequence that have higher conductivity and thus higher flow; and (iii) determine if areas of affected groundwater have an identifiable resistivity feature that can be used to guide the placement of additional monitoring wells. A total of nine ERI survey lines covering upgradient, the CPO facility, and downgradient areas of the site were completed as shown in Figure 1 (Enclosure A). The ERI survey lines are numbered 1 through 9, and several of such lines were broken into shorter segments to facilitate the implementation. These segments are designated by "A", "B", or "C" on the line number.

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Resistivity measurements were recorded using an Advanced Geosciences, Inc. (AGI) Supersting R8 resistivity meter and either 56 or 112 electrodes. Electrodes were spaced 6 meters (19.72 feet) apart to provide the best resolution to a depth of 250 feet below ground surface (bgs). Low amperage DC electrical current was applied at each electrode using a deep cycle 12-volt battery. The flow of electrical current in the ground was mapped by measuring the electrical potential at the ground surface using the AGI Supersting R8. Resistivity readings were collected using a hybrid dipole-dipole and gradient array. Data was collected using a roll-along procedure by moving either 28 or 56 electrodes after each data acquisition to ensure complete coverage along the length of each ERI survey line. Resistivity data were inverted using Advanced Geosciences's EarthImager2D and RES2DINV software developed by M.H. Loke. Electrical model data were imported into Surfer 8 software developed by Golden Software to produce color-coded cross sections or profiles for each ERI survey line displaying the distribution of resistivities between the various subsurface materials. The resistivity scale runs from 0 ohm-meter, which represents low resistivities (high conductivity) materials to a high of 100,000 ohm-meter, which represents highly resistive (low conductivity) materials. Each resistivity measurement was assigned a color from dark blue (0-9 ohm-meter) to red (100,000 ohm-meter). Typically, highly resistive materials (depicted in red) indicate competent bedrock with a low degree of saturation. Highly conductive materials (depicted in blue) indicate high saturation, high clay content, and/or elevated concentrations of dissolved ionic compounds. The focus of the ERI survey was to identify and generally locate the highly conductive water bearing zones within the subsurface.

The locations of ERI survey lines were recorded using a mobile global positioning system (GPS) receiver with differential corrections applied relative to a fixed base station receiver. ERI survey lines were also surveyed by Envirocan for elevation corrections.

Enviroscan's report of ERI survey results is provided in Enclosure B. The report provides a technical description of the survey methods and ERI survey line profiles constructed from the data gathered for the nine ERI survey lines completed at the Site, which are represented in Figures 2 through 9 in the Enviroscan report. Highly resistive areas/features (48,000 -100,000 ohm-meters) are depicted in red, moderately resistive areas/features (15,000 – 48,000 ohm-meters) in orange, and yellow. Highly conductive areas/features (0-150 ohm-meters) are shown in purple and blue; and moderately conductive areas/features (150-3,000 ohm-meters) in green. Typically, highly resistive areas (red color) indicate competent bedrock with a low degree of saturation. Conversely, highly conductive areas (blue color) indicate high saturation, high clay content, and/or elevated concentrations of dissolved ionic compounds. Anomalies with ERI survey results can be caused by man-made structures such as tanks, utilities, rail tracks, and piping. Areas with different resistivity values than the surrounding material are referred to as either conductive or resistive anomalies.

ERI Findings

In general, the profiles indicate that much of the saturated portion of the basalt sequence below the Site is moderately to highly conductive as evidenced by apparent resistivities in the 0-100 ohm-meter range. The unsaturated upper bedrock is indicated by high resistivity and the transition to saturated bedrock is associated with the transition to moderate to high conductivity. The interpretation of saturated versus unsaturated basalt is based on correlation with groundwater elevations in monitoring wells located in proximity to the ERI survey lines. When comparing the ERI survey line profiles and the lithology of the adjacent wells, there is no obvious resistivity characteristic that indicates a transition from saturated basalt to underlying sedimentary bedrock. The general pattern evident in the profiles is a horizontally layered subsurface comprising soil/overburden material, unsaturated basalt, bedrock and saturated basalt/sedimentary bedrock. Lateral variations and anomalies exist, but the predominant pattern is horizontal interfaces. Due to the highly conductive nature of the basalt bedrock, isolated basalt flow zones and interflow stratigraphy are not apparent in the profiles.

WSP reviewed the ERI survey profiles and available hydrogeologic information for monitoring and supply wells installed at the Site in preparing the interpretations presented below. The locations of highly conductive anomalies (less than approximately 50 ohm meters) identified in the profiles and referenced in the discussions below are depicted in Figure 2 prepared by WSP (Enclosed).

- <u>ERI Survey Line 1 Profile (N-S Orientation – Upgradient)</u>
  ERI Survey Line 1 was completed as a background (up-gradient) profile to provide an understanding of structural characteristics of the subsurface and also a baseline for groundwater chemistry. The survey line length was approximately 5,800 feet north to south (WSP Figure 1). The profile for ERI Survey Line 1 is shown in Figure 2 in the Enviroscan report. This profile exhibits the most resistive subsurface and lacks the large conductive anomalies evident in the remaining profiles completed on and downgradient of the CPO facility. The profile indicates fairly homogeneous structural characteristics in the bedrock with several relatively small zones of higher conductivity. A vertical shift is shown in the profile at approximately 3,760 feet which likely corresponds to the location of a known fault (WSP Figure 2, Enclosure A). The profile in combination with the available information on the site structural geology confirms that the area along ERI Survey Line 1 is underlain by a moderately conductive limestone and not the basalt sequence evident in the remaining profiles.

- <u>ERI Survey Line 2 Profile (SW-NE Orientation Along Haul Road)</u>
  ERI Survey Line 2 was completed as three (3) segments (2A through 2C) in order to avoid areas of restricted access and underground utilities (WSP Figure 1). The line extended approximately 7,500 feet along the haul road from the area south of the cooling ponds to the northeast of the Old Gyp Stack (F-GYP-0). Overall, the ERI Survey Line 2 profile depicts large conductive features at the depth of anticipated saturation with isolated smaller resistive anomalies observed near the surface (Enviroscan, Figure 3). Prominent highly resistive features are evident in the shallow subsurface between approximately 800 and 1,400 feet along the profile for ERI Survey Line 2A, which appear to be related to miscellaneous loose fill material/debris (WSP Figure 2). The soil-bedrock interface is evident along much of the profile and the upper 50 to 100 feet of bedrock is moderately resistive, corresponding to expected unsaturated conditions. Underlying the unsaturated bedrock is a highly conductive zone which is evident in the two northern segments (ERI Survey Lines 2B and 2C profiles) and is interpreted as saturated basaltic bedrock (WSP Figure 2). The two extensive zones of high conductivity—ERI Survey Line 2B profile from approximately 400 to 1,900 feet and ERI Survey Line 2C profile from approximately 0 to 2,000 feet—are likely associated with saturation and potentially associated with changes in groundwater chemistry (i.e., ionic groundwater).

- <u>ERI Survey Line 3 Profile (N-S Orientation West of F-GYP-0 and Decant Ditch)</u>
  ERI Survey Line 3 was completed to the west of F-GYP-O and extended a distance of approximately 6,500 feet south to north (WSP Figure 1). The soil-bedrock interface and unsaturated basalt bedrock in ERI Survey Line 3 profile are indicated by a higher resistivity

near the surface (Enviroscan, Figure 4). A highly conductive zone is evident from approximately 900 feet to 2,600 feet along the profile interrupted by a highly resistive feature at 1,900 feet (WSP Figure 2). A second highly conductive zone is present from 4,100 feet to 5,100 feet. Both highly conductive zones are immediately west of the Cell #1 and Cell #2/#3 of the Old Gyp Stack (F-GYP-0). WSP interprets the apparent highly conductive zones in ERI Survey Lines 2B and 2C profiles to represent saturated bedrock and possibly the effects of ionic groundwater chemistry. Sampling data for monitoring wells A-4 and A-7, located immediately west of ERI Survey Line 2, indicate such conditions exist in groundwater. The resistive anomaly centered around 1,900 feet at a depth of approximately 100 feet on ERI Survey Line 3 profile is interpreted as a potential structural change in bedrock.

- <u>ERI Survey Line 4 Profile (N-S Orientation on West Side of F-GYP-0 and Cooling Ponds)</u>
  ERI Survey Line 4 was completed to the west of ERI Survey Line 3 and extended a distance of approximately 6,500 feet south to north (WSP Figure 1). The profile for ERI Survey Line 4 indicates resistive, unsaturated, basalt bedrock along the entire profile length underlain by moderately resistive to conductive basalt and sedimentary bedrock where saturation is expected (Enviroscan, Figure 5). The survey line obliquely crosses the fault scarp between approximately 1,200 and 1,600 feet and vertical offset in top of bedrock is evident. Highly conductive bedrock is evident at depth between approximately 2,200 and 4,100 feet along the profile and may be representative of saturated bedrock, change in structural characteristics, and changes in groundwater chemistry (WSP Figure 2). Monitoring well data from A-8 and A-6 suggest the presence of ionic groundwater. A shallow, moderately resistive zone is present from around 4,200 feet to the north end of this profile and corresponds to areas with higher contact resistance and carbonate (tufa) deposits.

- <u>ERI Survey Line 5 Profile (N-S Orientation East of Route 34)</u>
  ERI Survey Line 5 was the western-most and comprised three (3) segments (5A, 5B, and 5C) totaling approximately 13,400 feet in length (WSP Figure 1). The profile for ERI Survey Line 5 shows higher resistivity near the surface which is indicative of the soil-bedrock interface and unsaturated basalt bedrock (Enviroscan, Figures 6 and 7). Several highly conductive and highly resistive features, the most prominent of which are three vertical highly resistive anomalies located between approximately 1,800 to 2,100 feet, 5,600 to 5,800 feet, and 7,800 to 8,200 feet (WSP Figure 2). The highly resistive anomalies evident between 1,800 and 2,100 and 7,800 and 8,200 feet appear to be indicative of bedrock structural changes and unsaturated conditions. The highly resistive anomaly evident between 5,600-5,800 feet is centered near the point where the survey line crossed the fault scarp and may be indicative of bedrock structural changes and unsaturated conditions in the fault. Highly conductive anomalies shown on the profile for ERI Survey Line 5C between approximately 760 and 1,700 feet most likely are attributable to changes in structural characteristics.

  This profile has been through several modeling iterations to verify the unusual resistive anomalies. Additional data trimming was conducted on the profile for ERI Survey Line 5B in order to remove suspect data from the interference, but the highly resistive anomalies remain. This may be associated with surface interference or a drastic change in bedrock structure. The quality of data correlation with the profiles for ERI Survey Lines 6, 7, and 8A is variable and may merit future corrections (i.e., remodeling).

- <u>ERI Survey Line 6 Profile (E-W Orientation South of Torgesen Ranch)</u>
  ERI Survey Line 6 extended a distance of approximately 2,700 feet in the area west of Cell #2/#3 of the Old Gyp Stack and crossed the fault scarp in a relatively perpendicular direction (WSP Figure 1). The ERI Survey Line 6 profile indicates resistive, unsaturated, basalt bedrock along the entire length underlain by moderately resistive to conductive basalt and sedimentary bedrock where saturation is expected (Enviroscan, Figure 8). A highly conductive zone east of the fault scarp at approximately 1,200 to 2,100 feet along the profile is interpreted as saturated bedrock influenced by structural changes and changes in groundwater chemistry (WSP Figure 2). The profile crosses the fault scarp between approximately 700 and 900 feet and vertical offset is evident in top of bedrock. A vertical feature of moderate to high resistivity at approximately 1,100 to 1,200 feet along the ERI Survey Line 6 profile may indicate structural deformation or lack of saturation.

- <u>ERI Survey Line 7 Profile (E-W Orientation Northwest of Cooling Ponds)</u>
  ERI Survey Line 7 was completed south of ERI Survey Line 6 and extended a distance of approximately 2,700 feet from southwest to northeast (WSP Figure 1). The survey line crossed the fault at an oblique angle. The profile for ERI Survey Line 7 indicates resistive, unsaturated, basalt bedrock along the entire length underlain by moderately resistive to conductive basalt and sedimentary bedrock where saturation is expected (Enviroscan, Figure 8). Highly conductive bedrock occurs at depth within several laterally isolated zones and is interpreted as areas influenced by structural changes and/or changes in groundwater chemistry. The ERI Survey Line 7 profile crosses the fault scarp between approximately 1,200 and 1,400 feet and vertical offset is evident in the top of bedrock (WSP Figure 2). A vertical area of moderate to high resistivity at approximately 1,200 feet along the profile may indicate structural deformation or lack of saturation.

- <u>ERI Survey Lines 8 and 9 Profiles (WSW-ENE Orientation North of Conda Road)</u>
  ERI Survey Line 8 was completed to the south of the cooling ponds in two segments (8A and 8B) to avoid road/rail crossings and areas with restricted access. ERI Survey Line 9 was completed to the south of the manufacturing area and crossed ERI Survey Line 1, which was located upgradient of the CPO facility. ERI Survey Line 8A covered approximately 2,700 feet, ERI Survey Line 8B covered about 1,100 feet, and ERI Survey Line 9 covered approximately 2,400 feet (for a total distance of approximately 6,200 linear feet). The profiles for ERI Survey Line 8 indicate resistive, unsaturated, basalt bedrock along the entire length underlain by moderately resistive to conductive basalt and sedimentary bedrock where saturation is expected (Enviroscan, Figure 9). Highly conductive bedrock occurs below the depth of anticipated saturation within several laterally isolated zones along the profile for ERI Survey Line 8A (at approximately 500-1,250 feet, 1,400-1,650 feet, and 1,750-2,400 feet) and along the entire length of the profile for ERI Survey Line 8B (WSP Figure 2). These highly conductive zones are interpreted as saturated bedrock with changes in groundwater chemistry. The ERI Survey Line 8A profile crosses the fault scarp between approximately 1,300 and 1,500 feet and vertical offset is evident in top of bedrock. Vertical areas of moderate to high resistivity between about 1,350 and 1,700 feet along the profile may indicate structural deformation or lack of saturation.

  The ERI Survey Line 9 profile presents a moderately resistive subsurface and lacks the extensive conductive features evident in other profiles completed on the CPO facility and downgradient areas. The profile is fairly homogeneous with several relatively small zones of higher conductivity. The zones of higher conductivity are interpreted as depositional changes associated with a thinning basalt sequence and a transition to sandstone bedrock.

This is supported by well log data from NW-9 and affirms the findings for the ERI Survey Line 1 profile.

Summary of Findings

The profiles for ERI survey lines completed on and downgradient of the CPO facility generally show that the saturated basalt bedrock is highly conductive. In particular, profiles for ERI Survey Lines 3, 4, and 5 completed to the west (downgradient) of the Old Gyp Stack exhibit extensive highly conductive zones which may be related to differences occurring within the subsurface, including changes in geology and/or groundwater chemistry. The three (3) west-east profiles that cross the fault at a high angle (ERI Survey Lines 6, 7, and 8A) show a recognizable offset in the top of basalt bedrock; however, this offset is obscured with depth and the fault plane is not completely resolved in the ERI survey line profiles. All three profiles show a moderate to highly resistive feature near the fault that indicates a change in structural geology or groundwater chemistry.

The profiles indicate variability in conductivity within the basalt bedrock that most likely relates to groundwater flow (preferential pathways) and/or changes in groundwater chemistry. However, the relationship between changes in bedrock and high conductivity cannot be adequately established. The additional data can be used to establish a better understanding of horizontal and vertical controls, and anomalies related to structural changes along the fault.

- Horizontal Control for Variation in Resistivity
  Several profiles exhibit lateral variation in apparent resistivity measurements and zones of high conductivity within the saturated bedrock (for example, ERI Survey Line 6 profile between 1,200 and 2,100 feet). In some cases this is suggested by data from nearby monitoring wells. ERI Survey Lines 4, 6, and 7 profiles show zones of high conductivity that correspond to areas where monitoring well data suggest ionic groundwater. Based on the ERI survey data it is not possible to ascertain if lateral transitions from high conductivity to high resistivity correspond to changes in bedrock or the presence of ionic groundwater.

- Vertical Control for Deep Conductive Anomalies
  Several profiles exhibit nearly continuous highly conductive areas within the saturated bedrock (ERI Survey Lines 2B, 2C, and 3 profiles). ERI Survey Line 2 is downgradient of the Main Production Area, and ERI Survey Line 3 is immediately downgradient of the Old Gyp Stack. Given the locations of these lines, their profiles are the most likely to be influenced by ionic groundwater. Monitoring well data suggests that ionic groundwater is present downgradient of the Old Gyp Stack, but there is no data on groundwater quality downgradient of the Main Production Area. The log for production well NW-5 provides lithologic correlation for the findings with respect to ERI Survey Line 3 profile. The presence of predominantly "soft lava", boulders, and clay below approximately 100 feet suggests a relatively high groundwater yield which could draw water vertically from shallower depths and result in high conductivity at depth. The logs for monitoring wells A-4 and A-7 indicate variability between hard basalt and cinders to a maximum depth of 120 feet. None of these wells penetrate the bottom of the basalt sequence. Based on the ERI survey data it is not possible to ascertain if the highly conductive areas along the profiles for ERI Survey Lines 2B, 2C, and 3 are attributable to structural features within the basalt, changes in the underlying bedrock, or ionic groundwater.

- <u>Structural Variability Across the Fault Scarp</u>
  ERI Survey Lines 6, 7, and 8 cross the fault scarp. In each of their profiles, a recognizable offset is evident in the elevation of the shallow resistive layer, interpreted as top of unsaturated basalt bedrock. Below the unsaturated bedrock, within the anticipated influence of the fault, are isolated conductive and resistive anomalies. However, the fault plane is not clearly resolved at depth. Based on the ERI survey data it not possible to ascertain if the isolated conductive anomalies are the result of structural features related to the fault zone or are associated with ionic groundwater.

<u>Proposed Seismic Reflection Survey</u>

A focused SR survey will be conducted to confirm the bedrock structure along key segments of the ERI survey and generate data necessary to ascertain if highly conductive zones result from structural geologic features in the bedrock or are associated with ionic groundwater. The SR survey will consist of five (5) separate segments totaling approximately 11,400 feet in length (WSP Figure 3, Enclosure A). The segments targets key highly conductive areas along certain profiles that are repeated in the other ERI survey line profiles. The SR survey segments are described below.

- SR Survey Line 1 will extend a distance of approximately 2,000 feet along ERI Survey Line 2B, which is east of the Old Gyp Stack. SR Survey Line 1 is intended to image a key area downgradient of the Main Production Area where ERI survey line profiles indicated extensive high conductive anomalies at depth. Seismic confirmation is necessary to resolve stratigraphic horizons or structural features and will be beneficial in assessing locations for potential placement of future groundwater monitoring wells.

- SR Survey Line 2 will extend a distance of approximately 2,000 feet along ERI Survey Line 3, which is west of the Old Gyp Stack. The survey area targets the location where highly conductive zones were identified on the profile for ERI Survey Line 3—between monitoring wells A-4 and A-7. Seismic reflection will provide insight on interpreting the ERI survey results at depth.

- SR Survey Line 3 will extend a distance of approximately 2,000 feet along ERI Survey Line 5B. The survey area targets the location of a vertical highly resistive feature identified along the fault scarp (4,700-5,700 feet on ERI Survey Line 5B profile). This SR survey will confirm if the highly resistive anomalies indicate structural changes related to faulting. Additionally, a 1,000-foot survey line will be placed in an area where ERI survey data suggests uniform, horizontal basalt stratigraphy (200-1,200 feet). The survey in this area will confirm the stratigraphy on the downthrown side of the fault and provide insight on interpreting the ERI survey results.

- SR Survey Line 4 will extend a distance approximately 2,400 feet along ERI Survey Line 6. This survey line targets the fault scarp and highly conductive zone identified between 1,200-2,100 feet in the ERI Survey Line 6 profile. Seismic reflection data will aid in determining the structural characteristics within the fault zone (e.g. wide brecciated zone or thin, well-defined fault plane) and will provide insight on interpreting the ERI survey results at depth.

- SR Survey Line 5 will extend a distance of approximately 2,000 feet along ERI Survey Line 8A across the fault scarp. Much like the profile for ERI Survey Line 6, the scope of SR Survey Line 5 targets several isolated highly conductive features in order to ascertain the structural characteristics within the bedrock and provide insight on interpreting the ERI results at depth.

Please call me if you have any questions.

Sincerely yours,

James P Bulman

James P. Bulman
Executive Vice President

JPB:tah:bdw
Hunton/Nu-west/Geophysical Survey/ERI/Reports/Nov 24 10 ERI FIndings

Enclosures

Enclosure A – Figures

Enclosure B – Final Report of ERI Survey Results

REFERENCES:
1. MAP I-557 GEOLOGIC MAP OF THE SODA SPRINGS QUADRANGLE, SOUTHEASTERN IDAHO. USGS, 1969.
2. ECOLOGICAL RISK ASSESSMENT, NU-WEST CONDA FACILITY. ENERCON SERVICES, INC., APRIL 2008.
3. GROUNDWATER ASSESSMENT DATA, FALL 2008. ENGINEERS INC. MARCH 2009

Figure 1 Drawing Number 00004217-003	WSP WSP Environment & Energy 4600 South Ulster Street Suite 930 Denver, Colorado 80237 (303) 850-9200	ELECTRICAL RESISTIVITY IMAGING TRANSECTS NU-WEST CPO FACILITY SODA SPRINGS, IDAHO PREPARED FOR HUNTON & WILLIAMS	DRAWN BY: EGC CHECKED: LT APPROVED:	SEAL DATE

REVISIONS

REV	DESCRIPTION		
1	Reviewed:	Chkd:	Appr.:
2	Reviewed:	Chkd:	Appr.:
3	Reviewed:	Chkd:	Appr.:

REFERENCES:
1. MAP I-557 GEOLOGIC MAP OF THE SODA SPRINGS QUADRANGLE, SOUTHEASTERN IDAHO. USGS, 1969.
2. ECOLOGICAL RISK ASSESSMENT, NU-WEST CONDA FACILITY. ENERCON SERVICES, INC., APRIL 2008.
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ELECTRICAL RESISTIVITY IMAGING TRANSECTS WITH CONDUCTIVE ANOMALIES

NU-WEST CPO FACILITY
SODA SPRINGS, IDAHO

PREPARED FOR
HUNTON & WILLIAMS

DRAWN BY	EGC
CHECKED	LT
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SEAL

DATE

REVISIONS

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1	Revised:	Chkd:	Appr.:
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3	Revised:	Chkd:	Appr.:

Figure 2

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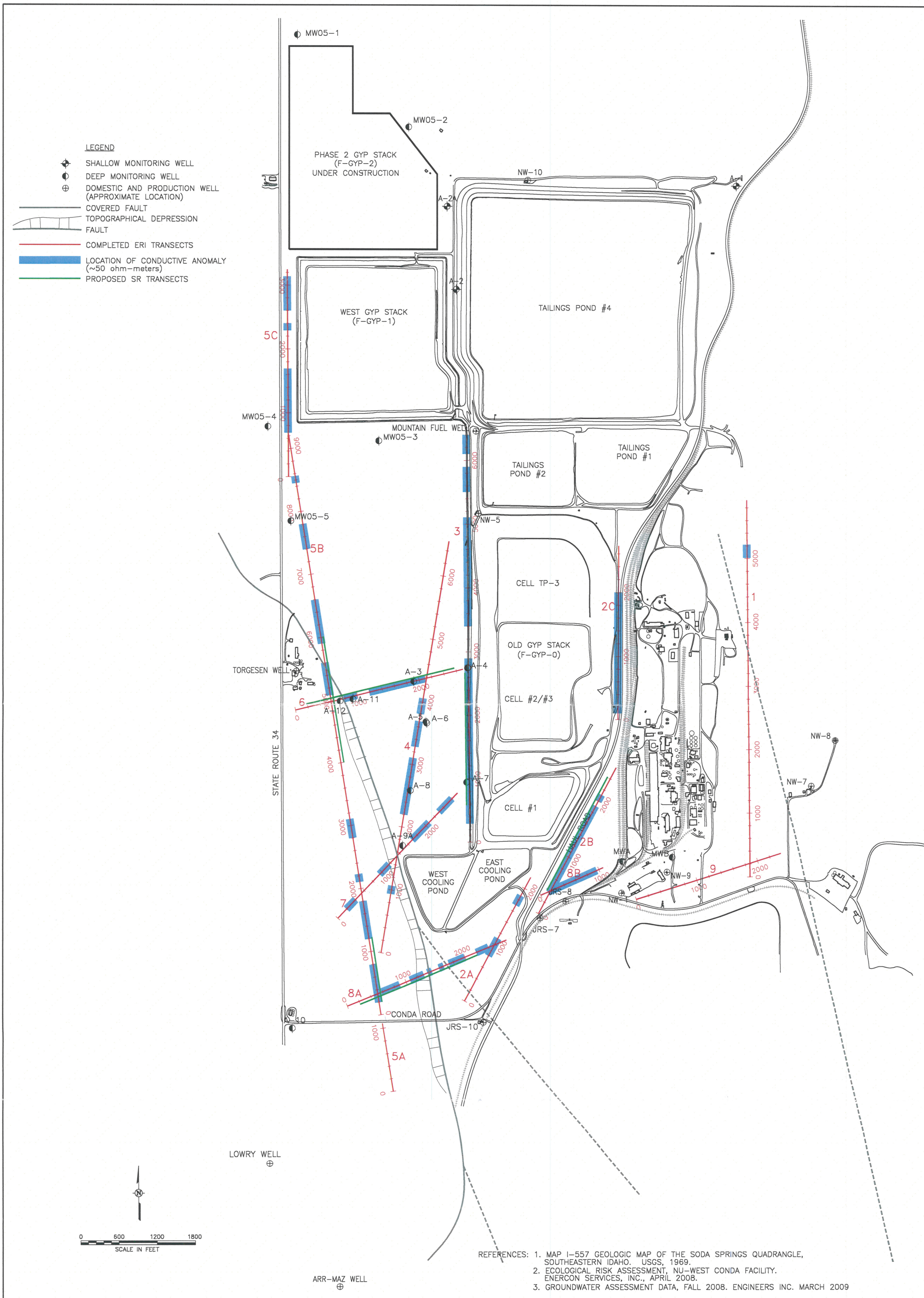

Figure 3

Drawing Number
00004217-003

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ELECTRICAL RESISTIVITY IMAGING TRANSECTS
WITH PROPOSED SEISMIC REFLECTION TRANSECTS

NU-WEST CPO FACILITY
SODA SPRINGS, IDAHO

PREPARED FOR
HUNTON & WILLIAMS

DRAWN BY	EGC
CHECKED	LT
APPROVED	

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Final Report
Geophysical Survey Results
Electrical Resistivity Imaging Profiles
Agrium US, Inc.
Soda Springs, ID
Enviroscan Project Numbers 061056 and 081043

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Prepared for: WSP Environment & Energy
Prepared By: Enviroscan, Inc.
November 9, 2010

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November 9, 2010

Mr. Timothy Huff
Senior Consultant
WSP Environment & Energy
205 West Park Street
Jackson, Missouri 63755

RE: Geophysical Survey Results – Final Report
Electrical Resistivity Imaging Profiles
Agrium US, Inc.
Soda Springs, ID
Enviroscan Project Numbers 061056 and 081043

Dear Mr. Huff:

Pursuant to our proposals dated July 1 and August 26, 2010, Enviroscan, Inc. (Enviroscan) has completed a geophysical investigation at the above-referenced site. The purpose of the survey was to locate hydrogeologically significant features and conditions beneath client-designated profiles within the facility utilizing electrical resistivity imaging. Fieldwork for the survey was completed from July 20 to July 30 (Project #061056), and from September 27 to October 9, 2010 (Project #081043).

Site Description

The site is located in and around the Agrium US Conda Phosphate Operation facility north of Soda Springs, Idaho. The survey profiles lie along primarily flat and unpaved roads, or within farm fields adjacent to the facility. Boring information provided by the client shows the site stratigraphy to consist of unconsolidated sediments over hard "basaltic" lava, underlain by clastic and chemical sedimentary rocks.

For this study, the client designated fourteen electrical imaging profiles (Profiles 1, 2A, 2B, 2C, 3, 4, 5A, 5B, 5C, 6, 7, 8A, 8B, and 9; see Figure 1) to be recorded.

Survey Methods

Electrical Imaging

Surface resistivity measurements involve driving an electrical current in the ground using two current electrodes at the ground surface. The apparent resistivity of the subsurface (essentially the mathematical inverse of terrain conductivity) is determined by measuring the potential difference or voltage between two potential electrodes with a known separation and position/orientation relative to the current electrodes. The depth and volume of the subsurface zone represented by the measured apparent resistivity is a function of the geometry of the current and potential electrodes located at the surface. The principles of electrical imaging are described in the accompanying Introduction to Electrical Imaging (Appendix A).

Using an AGI Super Sting R8/IP resistivity meter and Swift automated electrode-switching system, apparent resistivity readings were collected along the 14 profiles (see Figure 1). Along each profile, electrodes were spaced at approximately 20-foot intervals (6 meters or 19.7 feet). To collect electrical imaging data, a hybrid dipole-dipole and gradient array was used with 112 electrodes initially. As the measurement cycle proceeded, 28 or 56 electrodes were moved repeatedly, or "rolled", from the beginning of the array to the end of the array (roll-along) until the end of each profile was completed. Contact resistances between adjacent electrodes were recorded prior to each roll-along array along each profile to check for signal continuity and good ground electrical coupling. Resistivity readings were taken using a 1.2-second reading time, for three cycles with reversing polarity. If the standard error of the readings exceeded 5%, the cycle was repeated up to two more times.

The horizontal and vertical positioning of the profiles were surveyed using a Topcon RTK-Hyperlite Plus global positioning system (RTK-GPS), which can provides +/- 1cm accuracy. The measured apparent resistivities (ρ_a's) were plotted nightly (after each field day) as resistivity pseudo-sections depicting the apparent resistivity versus nominal survey depth for each profile in order to confirm data quality.

A hybrid array was used to maximize both the depth of the survey and the horizontal resolution. The dipole-dipole array completely separates the two current electrodes from the potential electrodes, is sensitive to near-vertical boundaries (e.g. fractures), and allows multiple potential readings to be recorded simultaneously to optimize survey time. Gradient array readings place the current electrodes at each end of the array with the potential electrodes situated between the current electrodes. The gradient array also allows collection of simultaneous readings, and provides higher signal-to-noise ratio than dipole-dipole when used for deep readings.

In post-field processing, the apparent resistivity pseudo-sections were mathematically inverted using EarthImager2D by Advanced Geosciences, Inc., to provide color-contoured electrical images of true resistivity versus depth along each profile as depicted in Figures 2 through 9. Appendix B lists the settings used to process the resistivity data in EarthImager2D as well as a list of the raw data files. In order to maximize the model depth, a depth factor of 1.5 was used in the mathematical inversion due to the low resistivity readings observed across the site. On these images, low resistivity (high conductivity) material is depicted in shades of blue, with high resistivity (low conductivity) material in shades of yellow and orange, and moderately resistive/conductive materials in transitional shades of green. Note that clay-rich and/or wet materials are typically represented by local resistivity lows (conductivity highs – shades of blue), while competent rock, as well as dry sands, gravels, or other porous or well-drained materials are typically represented by areas of resistivity highs (low conductivity – red to orange). Where groundwater or soil moisture contains dissolved solids or ions, resistivity may be extremely low. A horizontal to vertical flatness ratio of 1 was used in order to allow the modeling to produce horizontal and vertical variations in resistivity as the data dictated.

A comparison of the three inversion methods used in EarthImager2D was performed to help determine the best apparent method. Appendix C shows the results of Profile 5A utilizing each of the three inversion methods (Smooth Model, Damped Least Squares, and Robust). The Smooth Model Inversion Method clearly shows the most variations within the profile while the Robust Inversion Method appears to produce a very smooth model with fewer variations across the profile. Given these results, the Smooth Model Inversion Method was used for this survey. Minor changes to other parameter settings (e.g. boundary conditions, criteria for data removal, mesh divisions) do not appear to have a significant change in the results, whereas the choice of inversion method does.

Each inversion was run for eight iterations, and then paused to inspect the misfit between observed ρ_a's, and the ρ_a's predicted by the inversion model. Following this inspection, EarthImager2D allows trimming of the data, or deletion of readings with anomalously high misfit. For this study, only a single trim, involving less than 15% of the data, was performed for each inversion except for Profile 5B which required additional trimming.

Survey Results

Figure 1 depicts the locations of the electrical resistivity profiles. In general, the resistivity profiles were collected and are presented from south to north, with Profiles 6 through 9 oriented predominantly in a west-to-east direction. The location of each profile was marked in the field by the client at approximately 200-foot intervals and surveyed by Enviroscan at the completion of the survey using a Topcon RTK-Hyperlite Plus global positioning system for both horizontal and vertical positioning. Additionally, general lithology is presented on the profiles where well log information was provided by others.

The resistivity cross sections are depicted in Figures 2 through 9, with the general geologic lithology where available. The survey results indicate a low resistivity (high conductivity) layer over a moderately to highly resistive layer, underlain by a very low resistivity layer. Although the resistivities are relatively low, the results are consistent with the general lithology of unconsolidated sediments (relatively low resistivity) over lava (higher resistivity), underlain by sedimentary rocks and possibly sedimentary deposits (lower resistivity). The results also show significant variations in both the thickness and resistance of each inferred layer along each profile and across the site. Correlation between well logs and the resistivity data also varies significantly across the site.

Additionally, please note the low resistivity values observed on each of the profiles are significantly lower than expected. This may be due to the presence of ionic groundwater or soil moisture. This both inherently and unavoidably limits the depth of the investigation, and obscures more subtle resistivity variations due to changing lithologies or porosity.

The results indicate several anomalous areas along Profiles 2A, 2B, 3, and 5B with extreme resistivity values indicative of cultural interference. The central portion of 2A traverses over fill material with concrete (containing rebar) debris, while the resistivity high from along-profile distance 5300 to 6400 on 5B is located within the area of the Torgesen farm with several wire fences running both parallel and perpendicular to the profiles – which may have provided some interference with the electrical resistivity data. These anomalies, as well as the remaining high resistivity anomalies (e.g. multiple locations along Profile 5B), may be related to sources of shallow interference not visible on the ground surface; however, some may alternatively be geologic and not related to near-surface interference. Please note that Profile 5B was processed in multiple sections as well as utilizing the continuous resistivity profiler function in EarthImager2D. Each section was trimmed of noisy data before it was combined into one large profile which was then trimmed a second time to remove additional noisy data.

Limitations

The geophysical survey described above was completed using standard and/or routinely accepted practices of the geophysical industry and equipment representing the best available technology. Enviroscan does not accept responsibility for survey limitations due to inherent technological limitations or unforeseen site-specific conditions. However, we make every effort to identify and notify the client of such limitations or conditions.

We have enjoyed and appreciated the opportunity to work with you. If you have any questions, please do not hesitate to contact the undersigned.

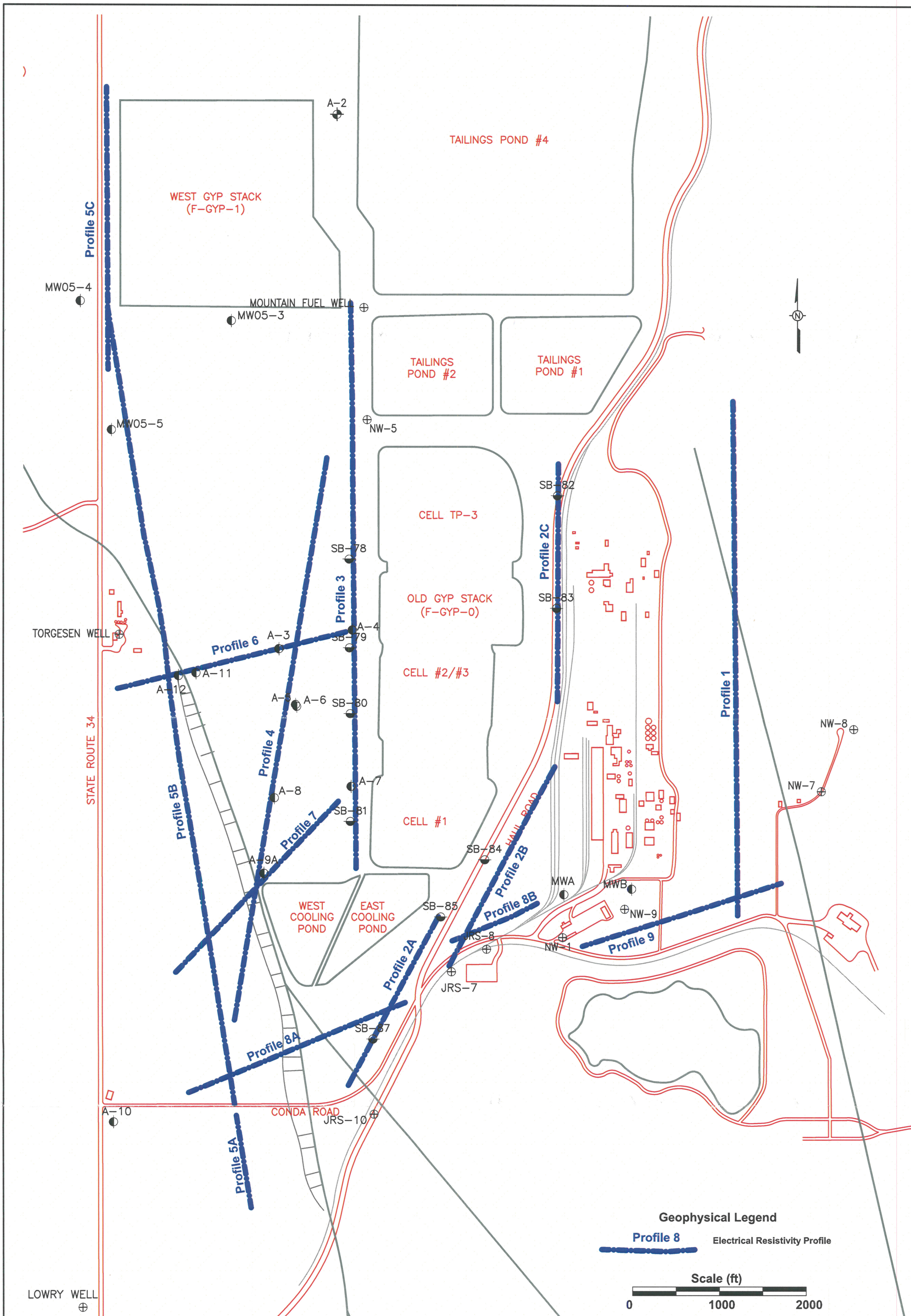
Sincerely,
Enviroscan, Inc.

Charles H. Rhine, M.Sc., P.G.
Senior Geophysics Project Manager

Technical Review By:
Enviroscan, Inc.

Felicia Kegel Bechtel, M.Sc., P.G.
President

enc.:	Figure 1:	Resistivity Profile Location Map
	Figure 2:	Apparent Resistivity Survey Results Profile 1
	Figure 3:	Apparent Resistivity Survey Results Profiles 2A – 2C
	Figure 4:	Apparent Resistivity Survey Results Profile 3
	Figure 5:	Apparent Resistivity Survey Results Profile 4
	Figure 6:	Apparent Resistivity Survey Results Profiles 5A & 5C
	Figure 7:	Apparent Resistivity Survey Results Profile 5B
	Figure 8:	Apparent Resistivity Survey Results Profiles 6 – 8A
	Figure 9:	Apparent Resistivity Survey Results Profiles 8B - 9
	Appendix A:	Introduction to Electrical Imaging
	Appendix B:	EarthImager 2D Processing Parameters and Data Files
	Appendix C:	Apparent Resistivity Inversion Method Results Profile 5A



Notes:

The information depicted on this drawing represents survey results on the date surveyed and can only be considered to be indicative of the general conditions existing on that survey date.

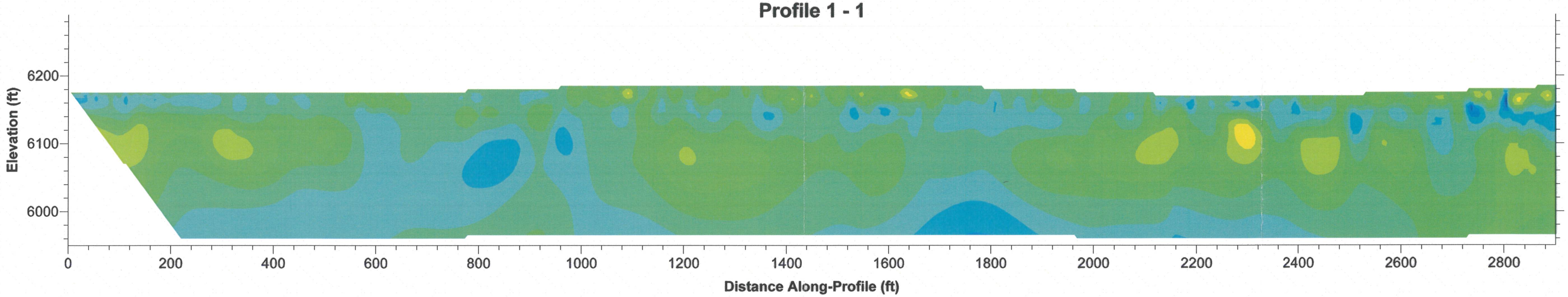
Coordinates in Idaho East State Plane (feet) NAD-83 Datum.

Basemap modified from client drawing 1023803(1)dwg.

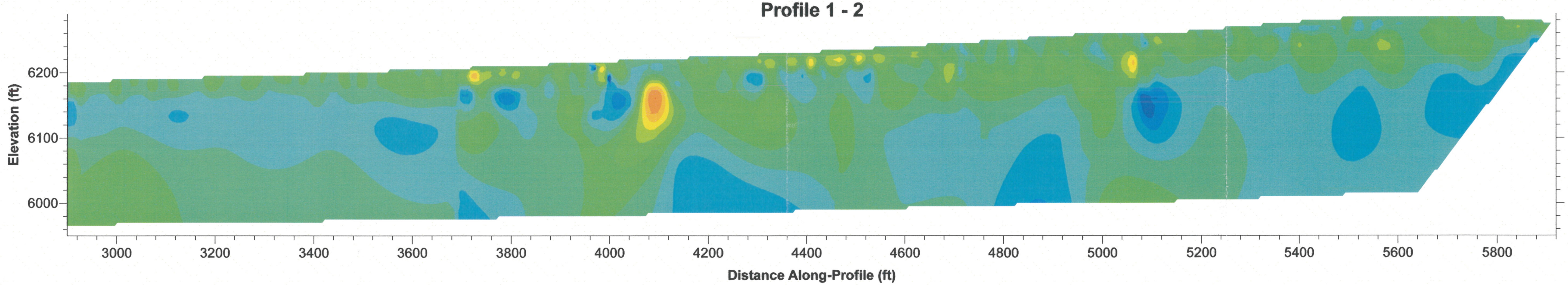
Prepared by:			Figure
Enviroscan, Inc. 1051 Columbia Avenue Lancaster, PA 17603 (717) 396-8922 www.enviroscan.com	Resistivity Profile Location Map	Agrium US, Inc. Site Soda Springs, ID	1
		Project Number: 081043 Revision/Issue: Rev. 11/08/10	
		Original Scale: 1" = 1000'	Drawn by: CHR Approved by: FKB

ENVIROSCAN, INC.

Profile 1 - 1



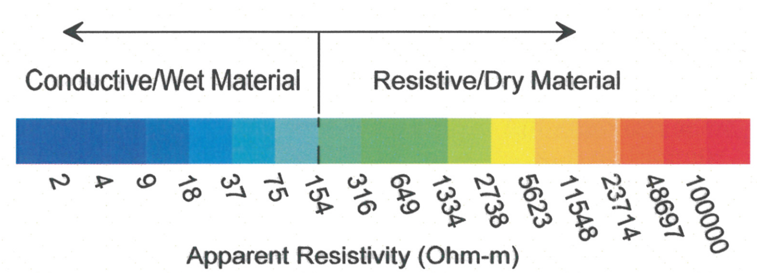
Profile 1 - 2



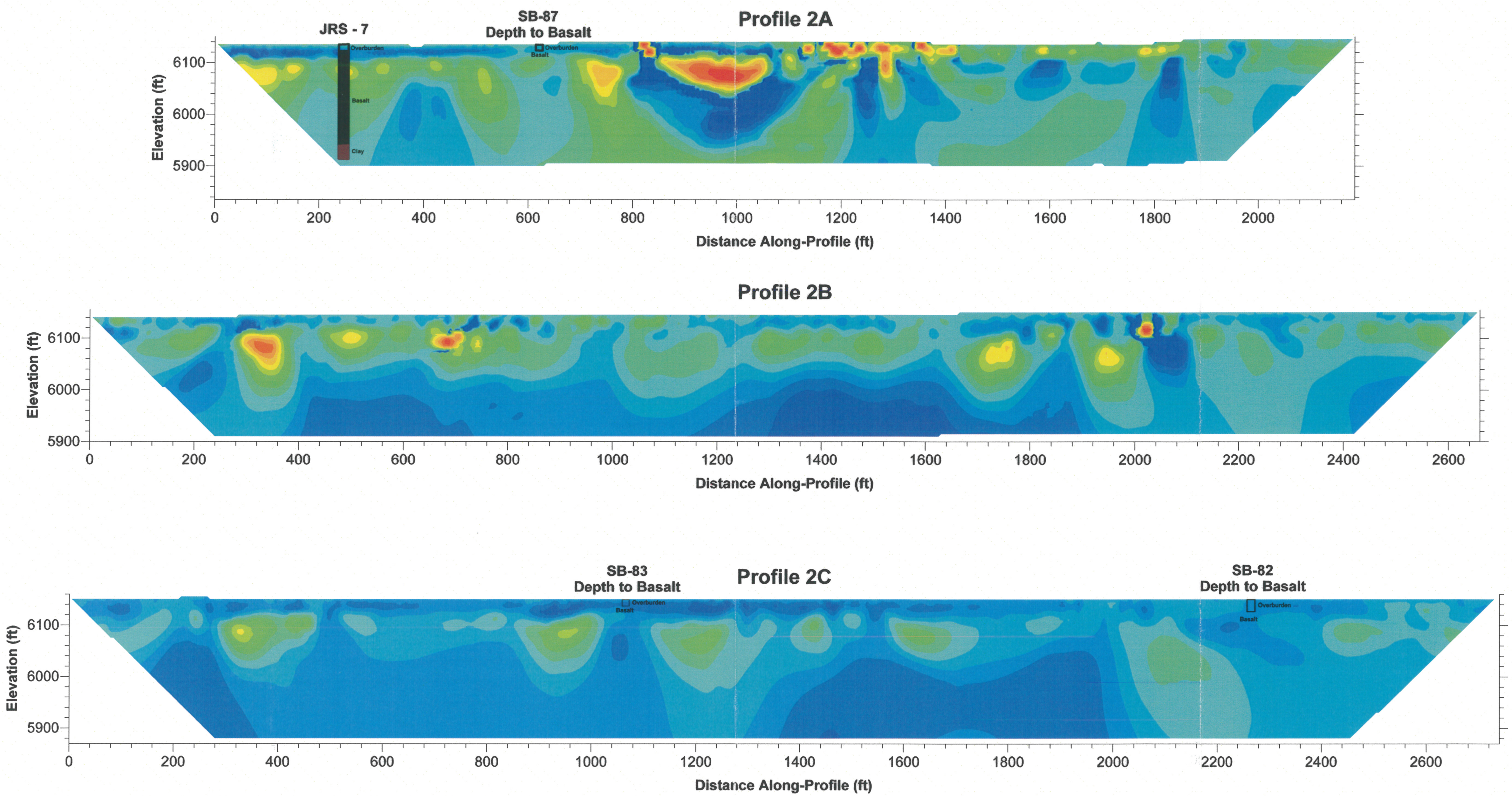
Notes:

Apparent resistivity cross sections collected with an AGI SuperSting R8. Profiles collected with a dipole-dipole-gradient array at 20-foot (6-meter) electrode spacings.

S → N



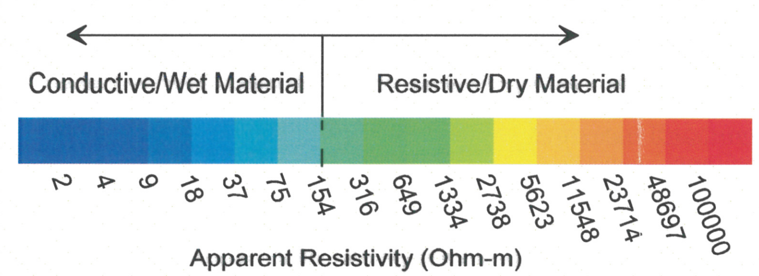
Prepared by:	Title:	Project Location:		Figure
ENVIROSCAN, INC. Enviroscan, Inc. 1051 Columbia Ave. Lancaster PA 17603 717-396-8922 www.envirsoscan.com	Apparent Resistivity Survey Results Profile 1	Agrium US, Inc. Site Soda Springs, ID		2
		Project Number: 081043	Revision/Issue: Rev. 11/08/10	
		Original Scale: Map 1" = 200'	Survey Ending Date	Drawn by: CHR / Approved by: FKB



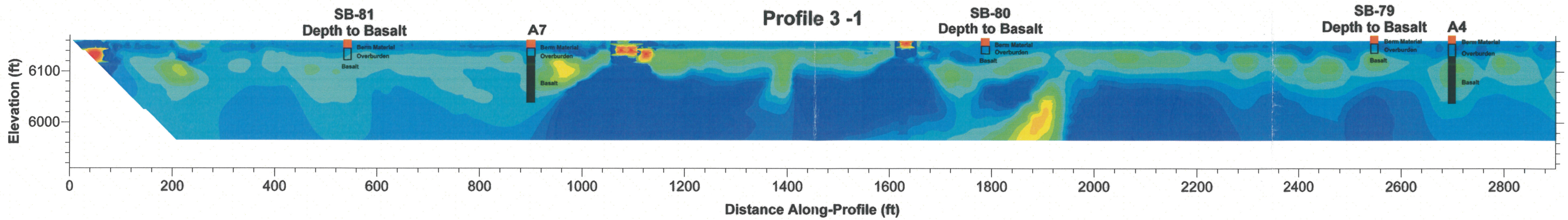
Notes:

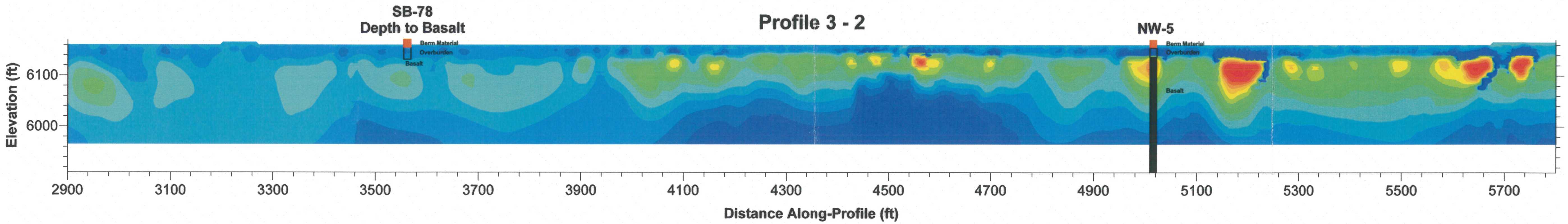
Apparent resistivity cross sections collected with an AGI SuperSting R8. Profiles collected with a dipole-dipole-gradient array at 20-foot (6-meter) electrode spacings.

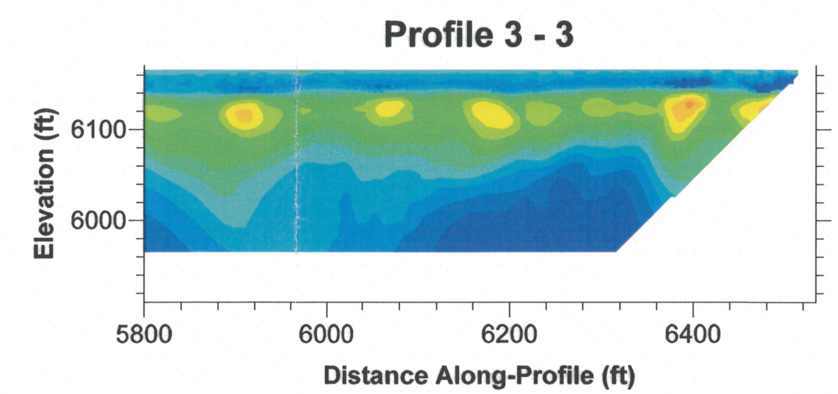
S → N



Prepared by:	Title:	Project Location:		Figure
Enviroscan, Inc. 1051 Columbia Ave. Lancaster PA 17603 717-396-8922 www.envrioscan.com	Apparent Resistivity Survey Results Profiles 2A - 2C	Agrium US, Inc. Site Soda Springs, ID		3
		Project Number 081043	Revision/Issue Rev. 11/08/10	
		Original Scale Map 1" = 200'	Survey Ending Date	Drawn by: CHR Approved by: FKB



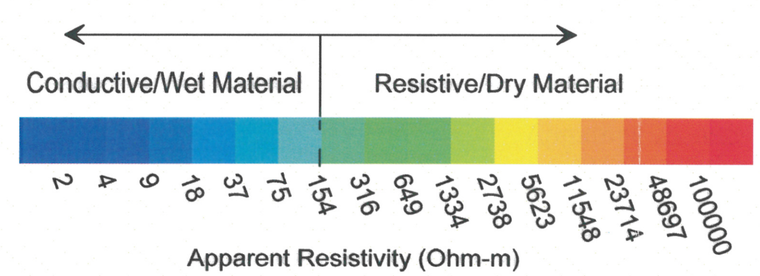




Notes:

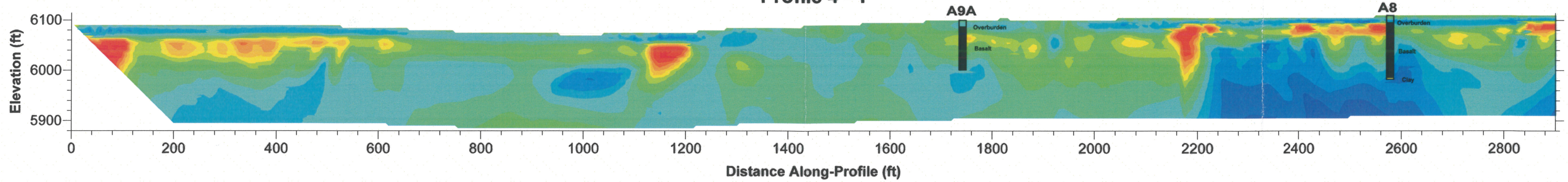
Apparent resistivity cross sections collected with an AGI SuperSting R8. Profiles collected with a dipole-dipole-gradient array at 20-foot (6-meter) electrode spacings.

S → N

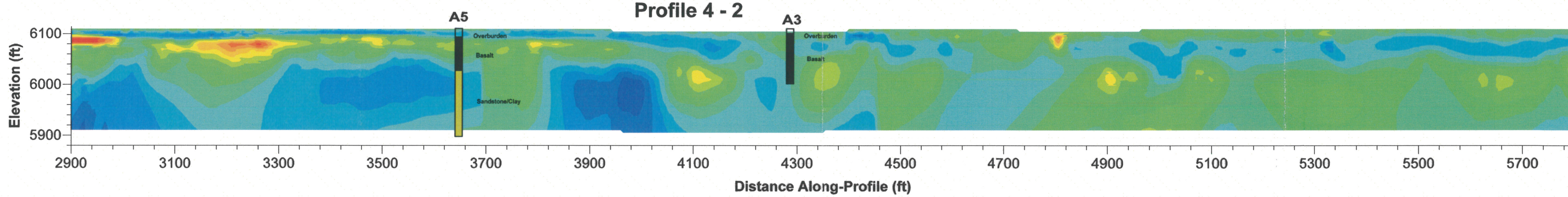


Prepared by:	Title:	Project Location:		Figure	
Enviroscan, Inc. 1051 Columbia Ave. Lancaster PA 17603 717-396-8922 www.envrioscan.com ENVIROSCAN, INC.	Apparent Resistivity Survey Results Profile 3	Agrium US, Inc. Site Soda Springs, ID		4	
		Project Number 081043	Revision/Issue Rev. 11/08/10		
		Original Scale Map 1" = 200'	Survey Ending Date	Drawn by: CHR	Approved by: FKB

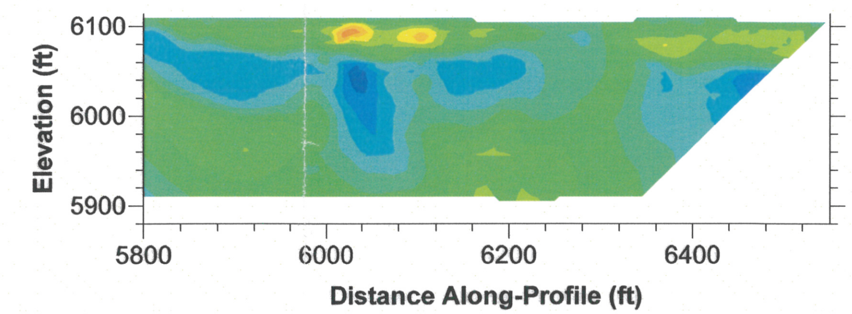
Profile 4 - 1



Profile 4 - 2



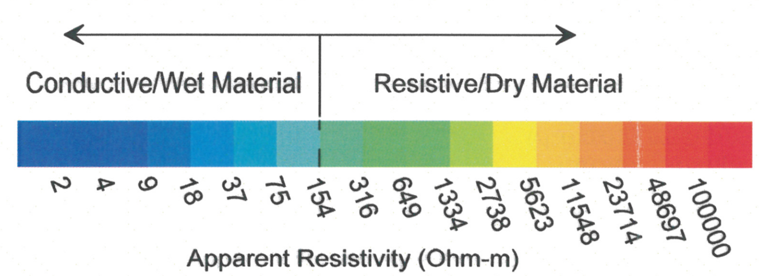
Profile 4 - 3



Notes:

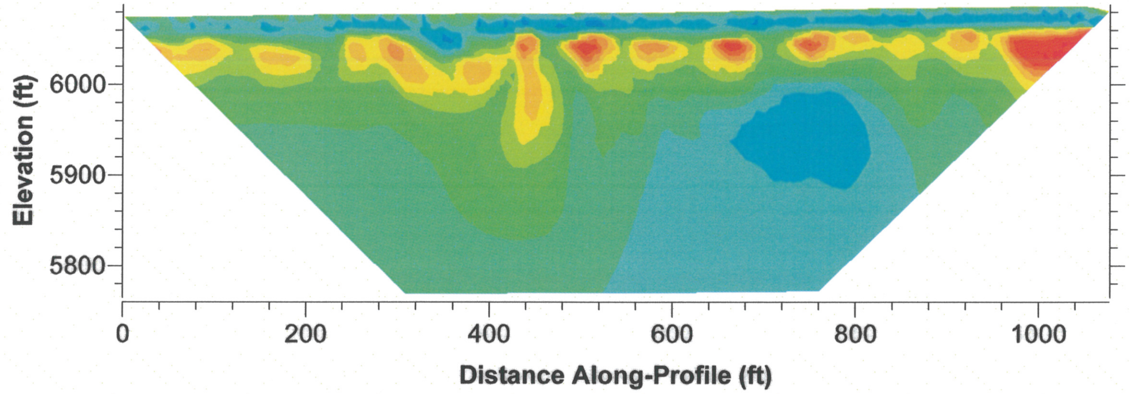
Apparent resistivity cross sections collected with an AGI SuperSting R8. Profiles collected with a dipole-dipole-gradient array at 20-foot (6-meter) electrode spacings.

S → N

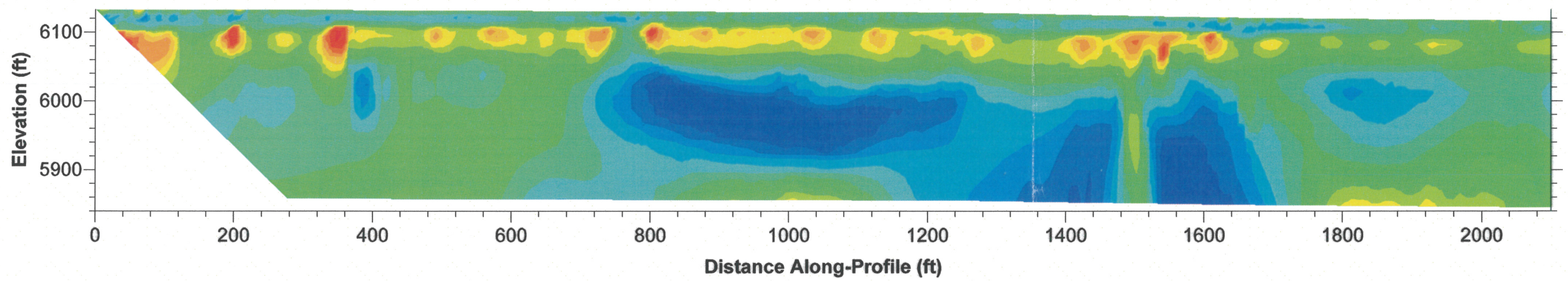


Prepared by:	Title:	Project Location:		Figure
Enviroscan, Inc. 1051 Columbia Ave. Lancaster PA 17603 717-396-8922 www.envirioscan.com ENVIROSCAN, INC.	Apparent Resistivity Survey Results Profile 4	Agrium US, Inc. Site Soda Springs, ID		5
		Project Number: 081043	Revision/Issue: Rev. 11/08/10	
		Original Scale: Map 1" = 200'	Survey Ending Date	Drawn by: CHR / Approved by: FKB

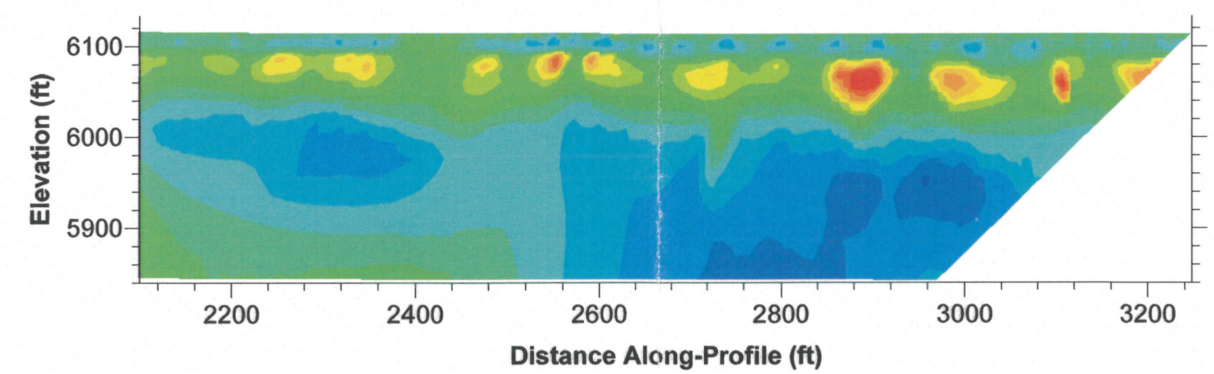
Profile 5A



Profile 5C - 1



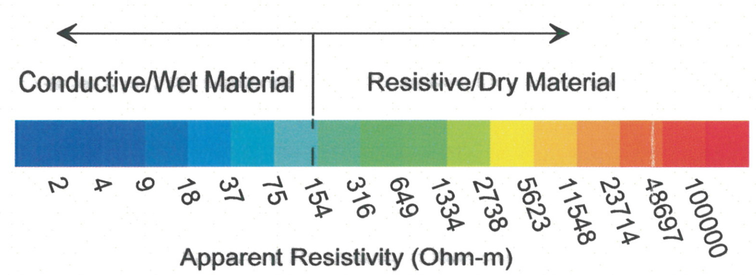
Profile 5C - 2



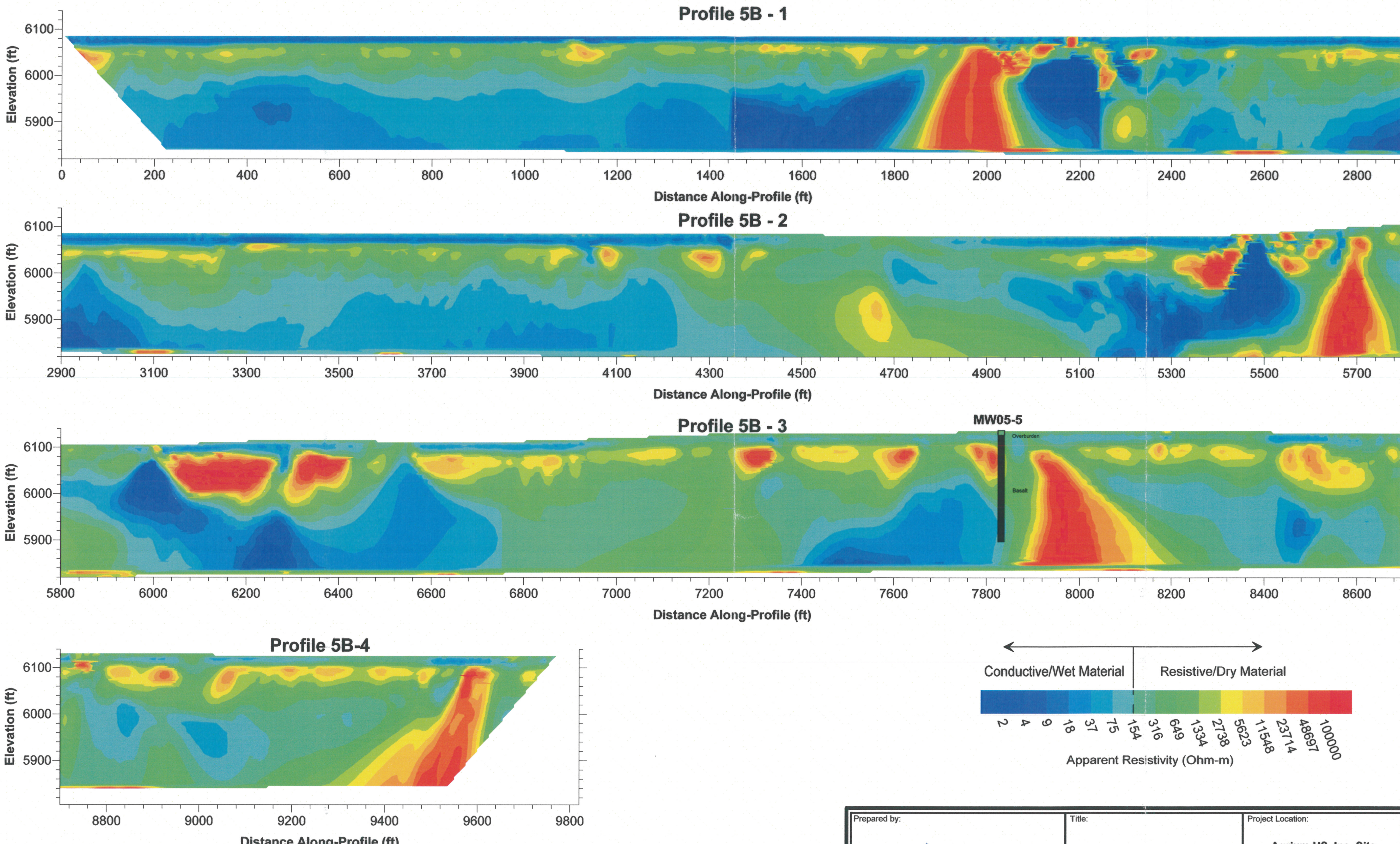
Notes:

Apparent resistivity cross sections collected with an AGI SuperSting R8. Profiles collected with a dipole-dipole-gradient array at 20-foot (6-meter) electrode spacings.

S → N



Prepared by:	Title:	Project Location:		Figure
Enviroscan, Inc. 1051 Columbia Ave. Lancaster PA 17603 717-396-8922 www.envrioscan.com	Apparent Resistivity Survey Results Profiles 5A & 5C	Agrium US, Inc. Site Soda Springs, ID		6
		Project Number: 081043	Revision/Issue: Rev. 11/08/10	
		Original Scale: Map 1" = 200'	Survey Ending Date	Drawn by: CHR / Approved by: FKB

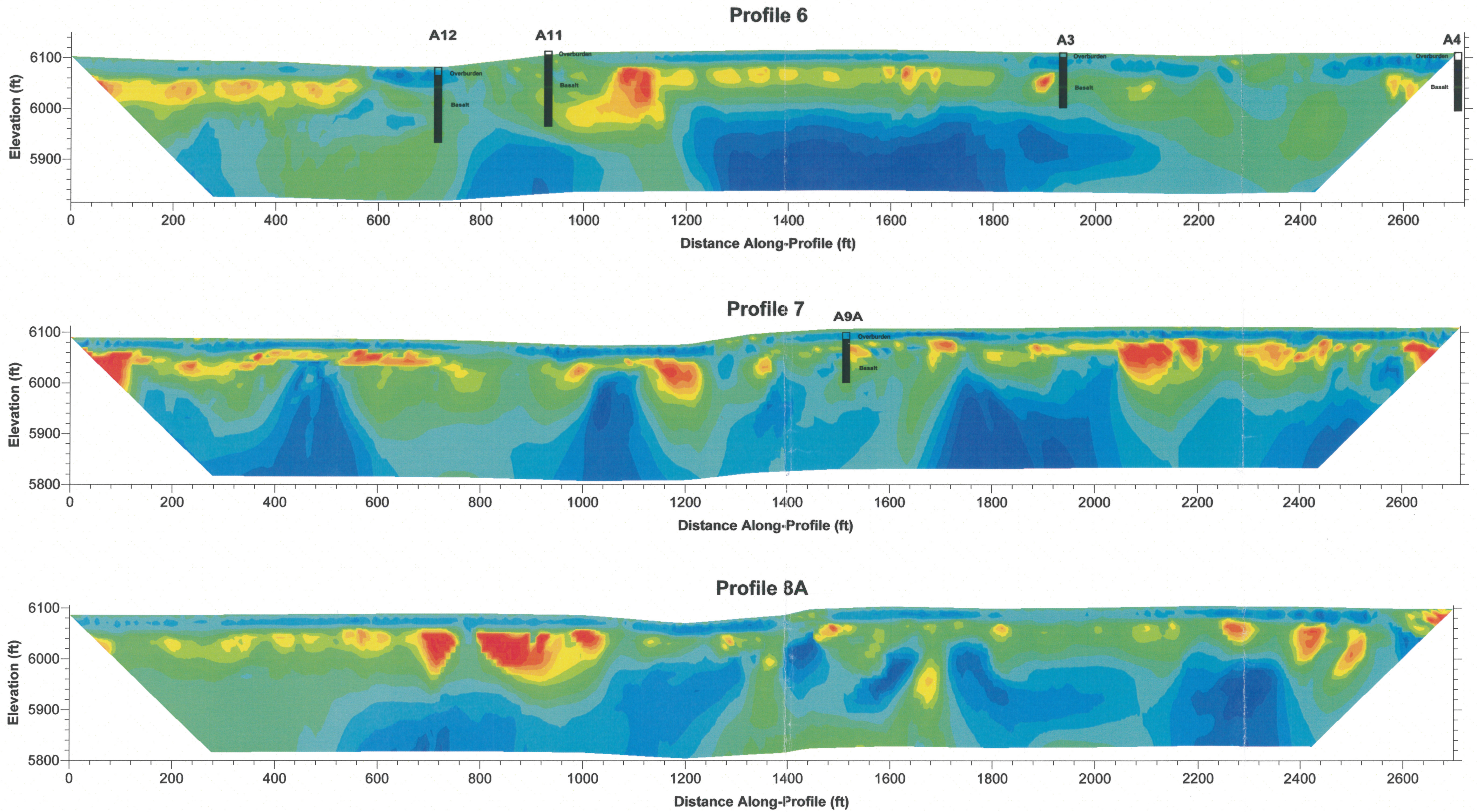


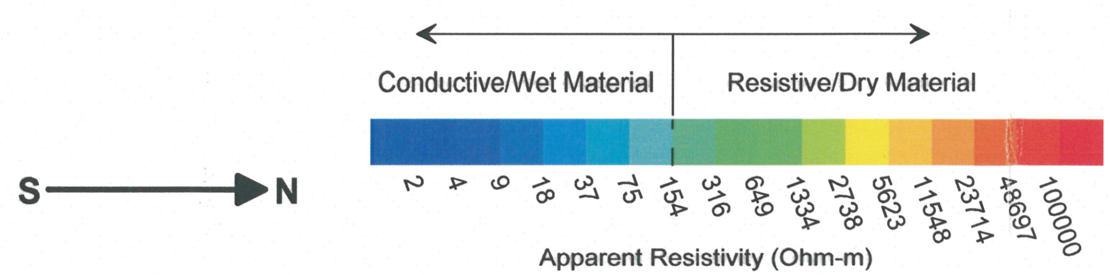
Notes:

Apparent resistivity cross sections collected with an AGI SuperSting R8. Profiles collected with a dipole-dipole-gradient array at 20-foot (6-meter) electrode spacings.

S → N

Prepared by:	Title:	Project Location:		Figure
Enviroscan, Inc. 1051 Columbia Ave. Lancaster PA 17603 717-396-8922 www.envrioscan.com	Apparent Resistivity Survey Results Profiles 5B	Agrium US, Inc. Site Soda Springs, ID		7
		Project Number 081043	Revision/Issue Rev. 11/08/10	
		Original Scale Map 1" = 200'	Survey Ending Date	Drawn by: CHR Approved by: FKB



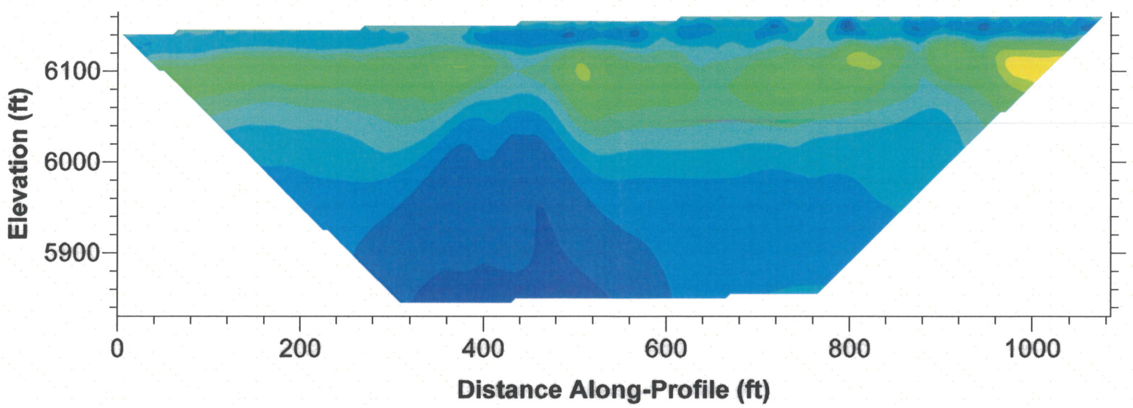


Notes:

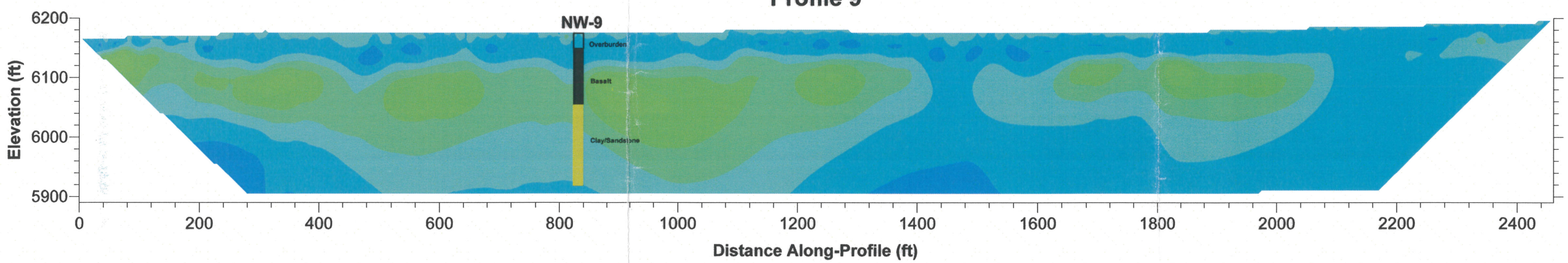
Apparent resistivity cross sections collected with an AGI SuperSting R8. Profiles collected with a dipole-dipole-gradient array at 20-foot (6-meter) electrode spacings.

Prepared by:	Title:	Project Location:		Figure
Enviroscan, Inc. 1051 Columbia Ave. Lancaster PA 17603 717-396-8922 www.envrioscan.com ENVIROSCAN, INC.	Apparent Resistivity Survey Results Profiles 6 - 8A	Agrium US, Inc. Site Soda Springs, ID		8
		Project Number: 081043	Revision/Issue: Rev. 11/08/10	
		Original Scale: Map 1" = 200'	Survey Ending Date:	Drawn by: CHR / Approved by: FKB

Profile 8B



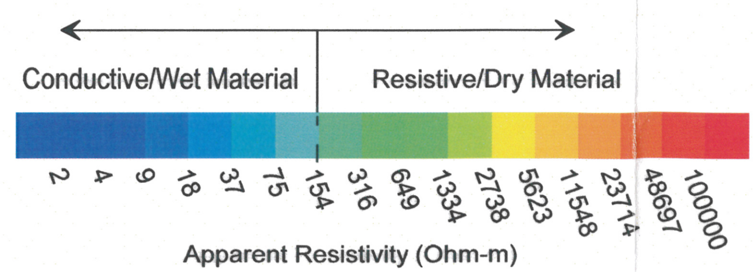
Profile 9



Notes:

Apparent resistivity cross sections collected with an AGI SuperSting R8. Profiles collected with a dipole-dipole-gradient array at 20-foot (6-meter) electrode spacings.

S → N



Prepared by:	Title:	Project Location:		Figure
Enviroscan, Inc. 1051 Columbia Ave. Lancaster PA 17603 717-396-8922 www.envrioscan.com ENVIROSCAN, INC.	Apparent Resistivity Survey Results Profiles 8B - 9	Agrium US, Inc. Site Soda Springs, ID		9
		Project Number 081043	Revision/Issue Rev. 11/08/10	
		Original Scale Map 1" = 200'	Survey Ending Date	Drawn by: CHR / Approved by: FKB

Appendix A

Introduction to Electrical Imaging

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ENVIROSCAN, INC.

Introduction to Electrical Imaging

by

Timothy D. Bechtel, Ph.D., P.G.

Energy

Electrical currents injected into the subsurface between electrodes pushed into the ground surface or non-intrusive, protected capacitors.

Sensitivity

Detects changes in electrical resistivity (the inverse of conductivity).

Basic Equipment

Either (traditional "steel spike electrode" method):

Steel spike electrodes (called current electrodes) connected by wires to a current source (to inject current), and steel spike electrodes (called voltage electrodes) connected to a microvolt meter (to measure the surficial distribution of electrical potentials). Note that current and voltage electrodes differ only by that to which they are connected (i.e. current source or microvolt meter, respectively.) Modern systems use arrays of electrodes (connected to multi-channel cables and an automated electrode-switching/recording system) to take measurements from electrodes at different locations and spacings (which adjusts the survey depth and resolution). Electrodes are hand-pushed into the ground surface along desired survey profiles.

Or (innovative "capacitively-coupled electrode" method):

Straight-wire capacitors which are capable of driving subsurface electrical currents and measuring surface potentials. The wire lengths and the distance between wires can be varied to adjust the survey depth and resolution. Capacitors are encased in torpedo-like protectors between the wire lengths, and the entire array (similar to a swimming rope with flotation buoys) is hand- or vehicle-towed along desired survey profiles.

Common Applications

Electrical imaging produces color-contour cross sections (commonly called electrical images) of subsurface electrical resistivity variations. These images can depict a target that has a different electrical resistivity from its surroundings, such as: buried wastes (pits, trenches, etc.); conductive groundwater plumes; resistive hydrocarbon plumes; foundation elements; water-bearing or mineralized faults or fractures; clay seams in bedrock; soil moisture anomalies; soil voids; clay layers bounded by sand or sand lenses bounded by clay; the top of competent (non-water-bearing) rock.

Principles

Electrical imaging can be performed by driving a harmless, very low amperage (e.g. 1 milliamp) DC electrical current in the ground between two steel spike electrodes. The depth to which the current flows is dictated by the separation of the two electrodes, and by the resistivity of subsurface materials. The flow of electrical current is mapped by measuring the electrical potential at various points of the ground surface using a very high impedance microvolt meter. Data suitable for determining a cross-sectional electrical image can be collected by taking many voltage readings with differing current electrode separations (i.e. different effective measurement depths) using different current electrode positions and voltage electrode positions (i.e. different locations along a profile). A two-dimensional image or cross-section is produced by employing electrodes in a linear array. Three-dimensional images (or color-contoured blocks of data) can be calculated using multiple linear arrays or grids of electrodes. The field-measured voltages, together with associated electrode positions, are mathematically inverted to provide the statistically best-fitting model of the subsurface resistivity distribution.

Electrical imaging can also be performed using straight-wire capacitors to drive currents and measure voltages. In this case, the length of the transmitter wire and the separation between the transmitter and receiver wires dictate the effective survey depth. Two- or three-dimensional data is collected by varying the lengths and separations of the transmitter and receiver capacitor wires for a given survey profile (i.e. the same profile is traversed several times using different wire lengths and separations).

Capabilities

Electrical imaging can detect and delineate a target that has a different electrical resistivity from its surroundings. Particularly good targets for electrical imaging include: electrically conductive clay seams, and water-bearing or mineralized faults or fractures in resistive bedrock; electrically resistive hydrocarbon plumes in moist electrically conductive soils; highly conductive electrolytic groundwater plumes (e.g. leachate or saltwater intrusion); highly conductive or resistive wastes buried in "normal" soils; soil moisture anomalies (e.g. dam seepage or incipient sinkholes).

Where site conditions allow, capacitively-coupled electrode systems can collect greater quantities of data in a given time (or at a given cost) than the traditional steel spike systems. The capacitive systems can also be used on asphalt pavement (where steel spike systems would require drilling many electrode holes).

Limitations

Electrical resistivities of differing materials have wide and overlapping ranges, making it impossible to positively identify a subsurface material based on its resistivity alone. For instance, profiling of the top-of-rock can be done by electrical imaging, but it is often difficult to specify exactly what resistivity contour corresponds with the top of rock (particularly where there is a weathering or saprolite zone). Since electrical resistivity (unlike seismic velocity) does not correlate with rippability or density, it is not typically the method of choice for rock profiling.

Based largely on a single well-publicized incident, electrical imaging has been promoted (by others) as a method for detecting bedrock cavities. However, since an air-filled cavity and competent rock are both electrical resistors, many cavities are not detectable using electrical methods (in this case, gravity would be the method of choice since air and competent rock have very different densities).

Electrical imaging data is susceptible to interference from underground utilities that capture and channel the subsurface current flow. This can be minimized in two-dimensional surveys by orienting the trace of an image perpendicular to any existing utilities.

Capacitively-coupled electrode systems suffer loss of signal penetration depth in highly conductive terranes. In addition, they are difficult to use in rugged or brushy terrain.

Survey depths using steel spike electrode systems can be limited by high contact resistances between the spikes and highly resistive surficial material.

Appendix B

EarthImager 2D Processing Parameters and Data Files

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EarthImager 2D Processing Parameters and Data Files

Initial Settings

Criteria for Data Removal

Minimum Voltage in mV:	0.5
Minimum abs (V/I) Ohm:	0.0005
Max Repeat Error %:	3
Min App Res (Ohm-m):	1
Max App Res (Ohm-m):	10000
Max Reciprocal Error (%):	5

Inversion Method

Smooth Model Inversion

Snap Electrode to Node (m): 0.003

Forward Modeling

Forward Model Method:	Finite Element Method
Forward Equation Solver:	Cholesky Decomposition
Type of Boundary Condition:	Dirichlet
Number of Mesh Divisions:	2
Thickness Incremental Factor:	1.1
Depth Factor:	1.5
Max Number of CG Iterations:	100
CG Stop Residual:	1.0e-06 (out)

CRP

Number of Electrodes Per Subsection:	112
Overlap:	30%

Raw Data Files

Data collected with an electrode spacing of 1 unit. Scaled in EarthImager to feet based on total profile distance.

Sting Data	Terrain File	Profile Distance (ft)
Profile 1.stg	Line 1.trn	5920
Profile 2A.stg	Line 2a.trn	2196
Profile 2B.stg	Line 2b.trn	2597
Profile 2C.stg	Line 2c.trn	2730
Profile 3.stg	Line 3.trn	6513
Profile 4.stg	Line 4.trn	6552
Profile 5A.stg	Line 5A.trn	1078
Profile 5B.stg	Line 5B.trn	9279
Profile 5C.stg	Line 5C.trn	3249
Profile 6.stg	Line 6.trn	2707
Profile 7.stg	Line 7.trn	2718
Profile 8A.stg	Line 8A.trn	2703
Profile 8B.stg	Line 8B.trn	1073
Profile 9.stg	Line 9.trn	2404

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Appendix C

Apparent Resistivity Inversion Method Results Profile 5A

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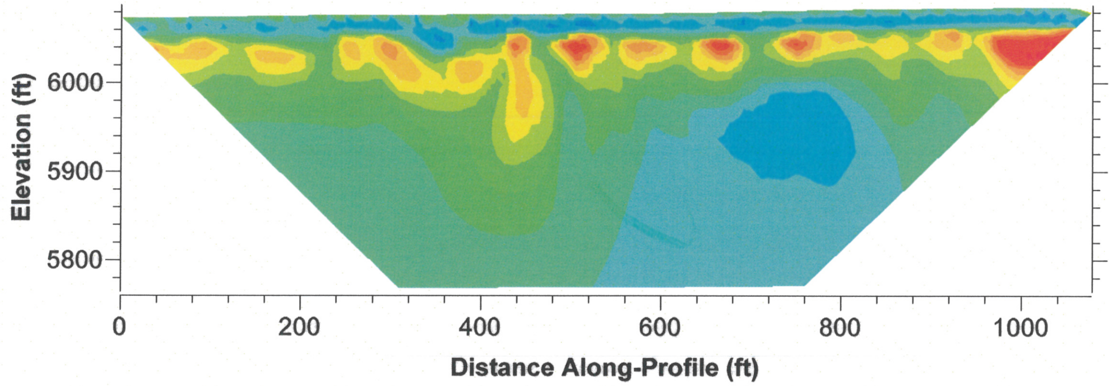
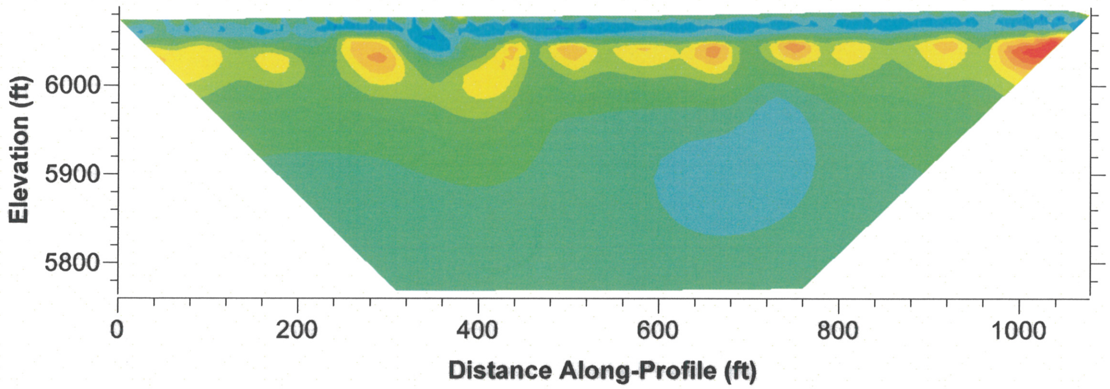
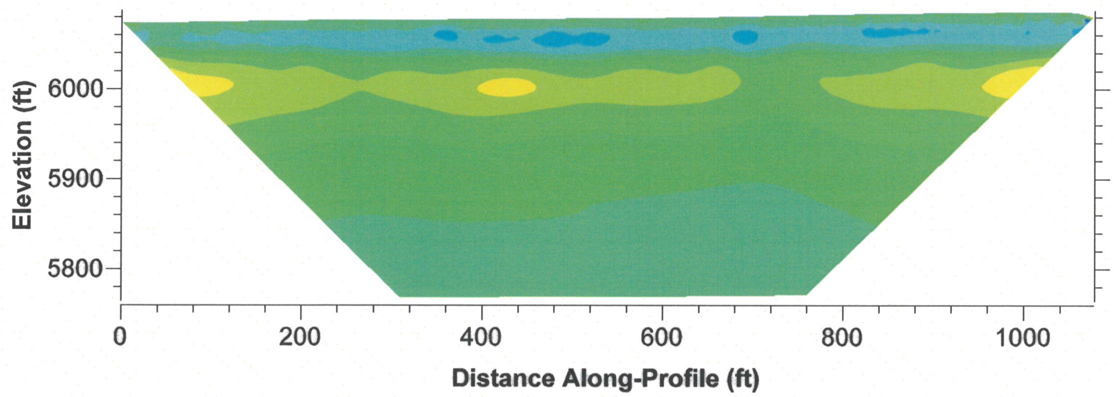
Profile 5A - Smooth Model Inversion Method



Profile 5A - Damped Least Squares Inversion Method



Profile 5A - Robust Inversion Method



Notes:

Apparent resistivity cross sections collected with an AGI SuperSting R8. Profiles collected with a dipole-dipole-gradient array at 20-foot (6-meter) electrode spacings.

Prepared by:	Title:	Project Location:		Appendix	
ENVIROSCAN, INC. Enviroscan, Inc. 1051 Columbia Ave. Lancaster PA 17603 717-396-8922 www.envrioscan.com	Apparent Resistivity Inversion Method Results Profile 5A	Agrium US, Inc. Site Soda Springs, ID		C	
		Project Number: 081043	Revision/Issue: Rev. 11/05/10		
		Original Scale: Map 1" = 200'	Survey Ending Date	Drawn by: CHR	Approved by: FKB